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Macroeconometric Analysis of Economic Activity in Thailand, 1962-1974

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MACROECONOMETRIC ANALYSIS OF ECONOMIC ACTIVITY IN THAILAND, 1962-1974

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and

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FOREWORD

This report summarizes work completed to date on macro models of the Thai economy. The project is a cooperative one conducted by the Division of Agricultural Economics (DAE) of the Ministry of Agriculture and Cooperatives, Royal Thai Government, and the Center for Agricultural and Rural Development (CARD) and the Department of Economics of Iowa State University. Funded by the Agency for International Development and the Royal Thai Government, it is one phase of a sector analysis project being undertaken in the DAE to provide models which can aid development and policies, particularly for Thai agriculture.

A series of macro models for the Thai economy have been undertaken to supplement the various models being developed for the agricultural sector of Thailand. These activities were undertaken not only because of the importance of national economic policies on employment, prices, and other variables in agriculture, but also because various policies enacted in behalf of agriculture also impact on other sectors of the economy.

The model reported is the first generation of a set of macro economic models which may be specified and quantified for the Thai economy. The current model is now being linked with a national programming model developed for the agricultural sector.

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This paper reports the preliminary results of a macroeconometric modeling effort carried out at the Division of Agricultural Economics, Ministry of Agriculture and Co-operatives, Royal Thai Government, over the two-year period from September, 1974 through August, 1976. This effort is part of a Sector Analysis Project being carried out by a team of advisers from Iowa State University in conjunction with the Division of Agricultural Economics under a 5-year contract with AID.

The ultimate purpose of the macroeconometric modeling effort is to link an econometric model of the nonagricultural sector with a linear programming model of Thai agriculture being developed in the project. This report, however, does not reflect this linking process, which at this time has not been completed. It presents two "stand-alone" models that treat the agricultural sector in a fairly aggregative manner. We believe that these models are of interest in themselves even though they represent a transition phase in the overall project. We are presenting them in this form to elicit comments and criticism that may improve future model generations.

This report may be excessively long in some respects, particularly in the discussion of economic and econometric procedure and in the presentation of data sources. We feel, however, that discussing these topics and presenting the sources is desirable in that one of the main functions of this report will be to serve as a basic reference document for future work in this area to be carried out in DAE and will hopefully serve as a self-contained document for the people doing this work.
There are many people, both American and Thai, who have been involved in this work to varying degrees, and we would like here to acknowledge their help without indicting them for what appears here. In DAE, we would like to especially thank Dr. Somnuk Sriplung, Chief of the division, for his great co-operation and assistance. Without his leadership, very little in the project would have been accomplished, if, indeed, it would ever have begun. A very special acknowledgement is made of the leadership of Dr. Earl O. Heady, overall director of the ISU project. In other Thai agencies, thanks go to Dr. Olarn Chaipravat of the Bank of Thailand and to Dr. Virabongsa Ramangkura of Chulalongkorn University. Of course, other members of the ISU team have had great input into this effort, and we would like to express our appreciation to them. They are Dr. Arthur Stoecker (Iowa State University), Dr. Keith Rogers (Western Illinois University), Dr. Leroy Blakeslee (Washington State University), Dr. Dennis Conley (University of Illinois), Dr. Herbert Fullerton (Utah State University), Dr. Charles Framingham (University of Manitoba), and Mr. Larry Kinyon, who provided excellent assistance in computer programming. Finally, we would like to thank Dr. Fletcher Riggs and Mr. David Lundberg of AID, who have provided, and continue to provide, many, many things to the project.

James A. Stephenson
Kajonwan Itharattana
I. INTRODUCTION

A. A Brief History of the Macro-modeling Effort in the ISU Sector Analysis Project in Thailand

The Iowa State University Sector Analysis Project was started in July 1973. The initial team consisted of three long-term advisors. In the early stages of the project, these three advisors, in conjunction with Thai staff members of the Division of Agricultural Economics in the Ministry of Agriculture, concentrated their efforts in the development of the methodology of constructing linear programming crop models for each of 19 agro-economic zones in Thailand.

Early in 1974 a fourth long-term advisor was added to the team in the area of transportation and marketing. Also, shortly thereafter, with the completion of early solutions of some of the zone LP models, one of the initial team members branched off into the area of statistical demand analysis of important agricultural commodities in Thailand. A second advisor began work on aggregating the zone models into regional LP models to study the differential impacts of agricultural policies on the various regions in Thailand. The third advisor continued the development of the LP models with the ultimate goal being the construction of a national linear programming model of Thai agriculture incorporating the statistical demand analysis and the transportation and marketing analysis.

The initial visualization of the project did not include any explicit and extensive consideration of the nonagricultural sector of the

economy, but as the agricultural modeling proceeded, the ISU and DAE staff began to feel that focusing only on the agricultural sector would give an incomplete picture of the Thai economy for policy simulation purposes. It was felt that identifying and quantifying the linkages between the agricultural and nonagricultural sectors was desirable to analyze properly the effects of nonagricultural policies on the agricultural sector and vice versa. Therefore, a fifth full-time ISU team member was added in September 1974 to investigate these linkages.

B. Some Methodological Considerations

1. The Construction of Macro-econometric Models in Developing Countries

The construction of very large, very sophisticated econometric models has been going on in developed countries, particularly in the United States, for about 15 years, and there is a large and growing literature on the techniques of specification, identification, estimation, forecasting, and simulation of these large models. The application of these techniques to developing countries is still a fairly recent phenomenon, however, and the number of macro-econometric models that has been constructed for developing countries is still small. The reasons for this are fairly obvious; lack of large and disaggregated time series data over a sufficient time period, lack of large-scale computing facilities, lack of a large enough group of well-trained applied econometricians in one place to carry out a major effort of this type, and so on. As time passes, though, these weaknesses are becoming mitigated, and attempts at macro-modeling are becoming more feasible.
The question then arises as to whether the modeling techniques and underlying theoretical specifications of the models in, say, the United States can be carried over to less-developed and, in some cases, quite structurally different economies. One often hears warnings against taking the neo-Keynesian macroeconomic theory underlying most of the large-scale macro-econometric models and applying it to developing countries. This warning is a partially valid one, but not totally. In a basically free-enterprise economy such as Thailand, where economic resources are allocated to some degree by the price system, the levels of the macro-economic variables are determined to a very large extent by the aggregate demands and aggregate supplies of produced goods and factors of production, given various technological and institutional constraints. Therefore, the problem of modeling any such economy necessarily involves the determination of these aggregate demands and supplies. What one must guard against is the blind application of neo-Keynesian macro theory without keeping clearly in mind the special institutional and economic characteristics of the economy being modeled.

In visualizing an economy it is instructive to go back to one of the most basic concepts of macroeconomics, that of the "circular flow." In its simplest and most aggregated form, assuming temporarily the absence of a government sector and an international trade sector, the economy is visualized as being composed of two sectors—the consuming sector and the producing sector. These two sectors interact economically in two ways. The producing sector hires the productive services of the consuming
sector through a factor-of-production market and rewards these services through factor payments (wages, salaries, rents, profits, etc.). Hence, there is a flow of money from the producing sector to the consuming sector and a flow of factor services from the consuming to the producing sector. The flow of money constitutes the money income of the consuming sector. The second interaction between the two sectors is that the members of the consuming sector use their money income to demand the products of the producing sector. In principle, then, in a closed economy which is in equilibrium, the flow of money between the two sectors must be equal, i.e., the amount of money that the consuming sector has to buy goods and services is equal to the amount of money it received in return for its factor services.

This, of course, is a very simplistic view of the world, but it constitutes the basic building block of macroeconomics. What is necessary to make it more realistic is to recognize that in the real world there are other factors at work. For example, in every society, there must be some form of government. The existence of government affects the equilibrium level of GNP in two ways. First, it supports itself by levying taxes on the private sector, which has the effect of decreasing GNP, and it spends money on goods and services, which has the effect of increasing GNP. The payment to government employees becomes income to them, and they in turn buy goods and services. The taxing and spending activities do not have symmetric effects, and therefore government
activity can have the net effect of raising or lowering the equilibrium level of money flowing through the economy.

Other things that must be taken into consideration include the existence of international trade, wherein goods and services produced in the economy are sold abroad, which constitutes an outside injection of money, raising the equilibrium money flow, and wherein goods and services produced abroad are purchased, which brings about a flow of money out of the economy. Secondly, the simplistic view of the economy assumes that individuals spend all of their factor incomes on goods and services in the time period in which they earn it. This, of course, is not true because individuals can save and borrow, thereby altering the time pattern of their demand and further altering the time pattern of the equilibrium level of money in the circular flow. In turn, the desires of individuals and firms to save and borrow necessitates the existence of a financial system, either formal or informal, wherein the money available from saving can be made available to potential borrowers. This financial system may be regulated by economic policy makers to achieve some desired goal in the time pattern of the equilibrium level of money in the circular flow. Also, the existence of foreign trade and a financial system adds further complications in that economic variables such as the aggregate price level and the level of foreign exchange become important.

This is just a thumbnail sketch of a macroeconomic system and is well known. However, it points out that an economic policy
maker must have a considerable amount of knowledge at his disposal in order to evaluate a proposed policy. Not only must he be able to judge the effects of the proposal on the equilibrium level of money in the circular flow, on the aggregate price level, on balance of payments equilibrium, and on the rate of economic growth of the economy, but he must also have some notion as to its effect on income distribution and its differential impacts upon various sectors of the economy. The role of the macro-economic theorist is to provide hypotheses about the effects of particular policies and the role of the macro-econometrician is, within the institutional and economic structure of a particular economy, to test these hypotheses and to provide the policy maker with a quantitative estimate of the effects of proposed policies.

2. Standard Macro-econometric Methodology

The standard procedure in the construction of macro-econometric models is to begin with a set of national income accounting identities. These accounting identities represent the amount of money flowing through the various parts of the circular flow. For example, an accounting identity that measures the total aggregate demand for goods and services might be written:

\[
\text{Gross Domestic Product} = \text{Private Consumption of Goods and Services} + \text{Government Consumption Expenditures} + \text{Gross Private Fixed Capital Formation} + \text{Gross Government Fixed Capital Formation} + \text{Total Exports} - \text{Total Imports}.
\]

An accounting identity measuring the flow of money through the factor of production market might be written:
Gross Domestic Product = Wages and Salaries + Rents + Interest Payments + Indirect Taxes + Capital Consumption Allowances.

There are many variations on these identities, both in terms of defining other economic variables (e.g., national income, personal income, personal disposable income, etc.) and in terms of disaggregating the various components in the identities (which will be seen in the models that will be presented). The form that the disaggregation will take will depend on the purposes of the model builder, data availability, and many other considerations.

In general then, the construction of a macro-econometric model involves the setting up of a system of national income accounting identities appropriate to the model builder's needs, determining which of the economic variables he wishes to explain and forecast, i.e., the jointly dependent variables (JDV), and which economic variables he wishes to take as determined outside the model, i.e., the predetermined variables (PDV). He then attempts to specify the functional relationships among the jointly dependent and predetermined variables. For a model with G jointly dependent variables and K predetermined variables, the general linear presentation of a simultaneous equations econometric system will be:

\[
\begin{align*}
\beta_{11} y_1 + \beta_{12} y_2 + \ldots + \beta_{1G} y_G + \gamma_{11} z_1 + \gamma_{12} z_2 + \ldots + \gamma_{1K} z_K &= U_1 \\
\beta_{21} y_1 + \beta_{22} y_2 + \ldots + \beta_{2G} y_G + \gamma_{21} z_1 + \gamma_{22} z_2 + \ldots + \gamma_{2K} z_K &= U_2 \\
\vdots & & \vdots \\
\beta_{G1} y_1 + \beta_{G2} y_2 + \ldots + \beta_{GG} y_G + \gamma_{G1} z_1 + \gamma_{G2} z_2 + \ldots + \gamma_{GK} z_K &= U_G
\end{align*}
\]
where \( y_1, \ldots, y_G \) are the jointly dependent variables;
\( z_1, \ldots, z_k \) are the predetermined variables;
\( u_1, \ldots, u_G \) are the stochastic elements in each equation;
\( \beta_{ij} \) are the structural parameters associated with the JDV;
\( (i = 1, \ldots, G; \ j = 1, \ldots, G) \)
\( \gamma_{il} \) are the structural parameters associated with the PDV;
\( (i = 1, \ldots, G; \ l = 1, \ldots, K) \).

This system of equations constitutes a system of structural equations with the \( \beta_{ij} \) and \( \gamma_{il} \) being structural parameters. In matrix notation, this is written:

\[ 1') \quad BY + GZ = U. \]

Of course, the practical problems of specification center around deciding, on economic theory and statistical criteria, which of the jointly dependent and predetermined variables will be included in each of the structural equations and which will be excluded.

Given data on the JDV and PDV, we want to estimate the values of the structural parameters using standard statistical inference procedures, i.e., to describe as well as possible the existing structure of the economy. The description of the structure of the economy provides the model builder and economic policy maker with a static picture of the economy with which he is dealing.

The next step, and perhaps a more important one from a policy point of view, is to use this model (1) for forecasting the effects of changes in the variables that are considered exogenous to the system, and (2) for
forecasting the effects of particular policy actions. This is done by rewriting our structural model, \( BY + GZ = U \), as

\[
Y = -B^{-1}GZ + B^{-1}U \\
= \pi Z + V
\]

where \( \pi = -B^{-1}G \)

\[
V = B^{-1}U.
\]

This is called the reduced form of the structural model, and it is the form of the model used for forecasting purposes because it expresses each of the JDV as a function of all the PDV. The matrix of reduced form coefficients, \( \pi \), can be obtained once the matrices of the structural parameters, \( B \) and \( G \), have been obtained. Alternatively, they can be obtained directly by regressing each of the JDV on all of the PDV. In either case, the reduced form coefficients constitute impact multipliers, i.e., they indicate what the effect of a change in the value of one of the PDV will be upon the equilibrium values of the jointly dependent variables.

The general question of forecasting with econometric models can be broken into two parts:

1) forecasting under unchanged structure;
2) forecasting under changed structure.

The first of these assumes that for the forecast period the values of the structural parameters will remain unchanged. Hence, all that is necessary to forecast the effect of a change in one of the PDV are estimates of the reduced form parameters. As noted above, these may be obtained directly, so that for forecasting under unchanged structure, it is not necessary to get estimates of the structural parameters.
Forecasting under changed structure poses a more difficult problem. By definition, a change in structure means that the values of at least one of the structural parameters will be different in the forecast period than in the estimation period. Because there is no direct way to estimate the reduced form parameters for the forecast period, i.e., there are no available observations, it is necessary to have estimates of the structural parameters for the sample period. These estimates may be obtained only if the equations in the model are identified, or are over-identified. Structural equations are said to be identified or over-identified if unique estimates of the structural parameters can be obtained given estimates of the reduced form parameters. A great deal of attention is paid in the econometric literature to the ways in which these estimates may be obtained and which we will not discuss here. In any event, once they are obtained, by whatever estimation technique, forecasting under changed structure involves the changing of one or more of the elements in $B$ or $G$ (presumably an informed guess on the part of the model builder), and then recalculating the "new" reduced form matrix (called the "derived reduced form") and then proceeding as before. The reason that forecasting under changed structure is important in macro-econometric modeling is that many policy changes involve changing the economic structure, e.g., changing the tax structure, government expenditure, and taxation patterns, and so on. By applying reduced form analysis to various proposed policy changes, one is able, at least in principle, to forecast the effects of these policy changes on the values of the jointly dependent variables in the system.
This, of course, oversimplifies the problem greatly. It is only the general methodological approach. The real difficulty lies in the appropriate specification of the equations of the model. Moreover, a model is never just specified once and used forever. It must be continuously updated and revised, and thereby, hopefully, improved.

3. The Scope of the Models Presented in this Paper

The macro-econometric modeling effort in the present project must necessarily take on a different form than the standard one just presented. Because of the very great importance of agriculture in the Thai economy, the primary focus of the overall ISU Sector Analysis Project is to describe Thai agriculture in an extensive and disaggregated manner as possible and to investigate the effects of alternative policy proposals with particular emphasis on increasing-agricultural production and income. This means that the macro-modeling of the nonagricultural sector must be geared to the investigation of the interactions between the nonagricultural sector and agricultural sector.

Second, the approach of the national agricultural model is linear programming, whereas that of the macro-econometric model is time series regression analysis, as already discussed. This means that two models involving different techniques must be linked together in order to solve them simultaneously. This poses some difficult problems, both in terms of econometrics and computer programming, but linking the models remains the ultimate purpose of the project.

The models in this paper do not reflect this linking process. They reflect the construction of two "self-contained" models of the Thai economy
which have considerable disaggregation in the nonagricultural sector and a fairly aggregated treatment of the agricultural sector. Model I, presented in Section II, is a 45 equation model that was constructed specifically as linear in both parameters and variables. Moreover, it is a completely "real" model in that there is no consideration of the monetary sector and therefore no consideration of the determination of various aggregate price levels. Model I was constructed in this fashion for the following reasons. Because the national agricultural model is in a totally linear form, the initial methodological problems involved in the linkage of the two models would be reduced if the macro-model was likewise linear in all regards. The monetary and price sector was excluded simply because it is a very difficult sector to model in Thailand (for reasons discussed in Section III) and it was desirable to have a "complete" model to start the linking process, even if incomplete. Model II, presented in Section III, also is a self-contained model that attempts to correct some of the deficiencies in Model I. It represents nonlinearization of variables (though not of parameters) and includes a monetary and price sector.

Although these models may be regarded as transitional models in that they have been constructed in preparation for linking with the national LP model, they are of interest in themselves, and therefore are presented in this report. The discussion of the linking process and the results of this process will be presented in a second report that will be forthcoming in the near future.
II. MODEL I: A MACRO-ECONOMETRIC MODEL LINEAR IN PARAMETERS AND VARIABLES

A. Introduction

As stated above, Model I is a 45-equation model, linear in both parameters and variables. It consists of 36 behavioral equations and 9 identities. The behavioral equations consist of seven general groups of equations:

1) Private Personal Consumption Equations;
2) Government Expenditure Equations;
3) Export Equations;
4) Import Equations;
5) Gross Fixed Capital Formation Equations;
6) Output Equations; and
7) Income Distribution Equations.

In general, the definition of variables and the method of aggregating variables were chosen to match the definition of variables used by National Economic and Social Development Board (NESDB) in the national accounts. Although one would perhaps prefer alternative definitions and would like to have greater disaggregation in some series, these accounts do constitute the primary source of national income data, and it was preferable to align the model to them to as great an extent as possible. (For a detailed description of data sources, see the Data Appendix.)

The equations in the model are estimated by Ordinary Least Squares, using annual data for the sample period, 1962-1974. Two-state Least Squares
cannot be used directly because of the small number of time series observations. An alternative here would be to use principal components to estimate the first stage regressions, but at present there is no principal components program operational at DAE, and so we have stayed with Ordinary Least Squares. Re-estimation of the structural parameters using principal components will be carried out in the near future. In Section B, we present the equations and variables of Model I. The figures in parentheses are t-statistics.

B. Equations of Model I

**PRIVATE CONSUMPTION EXPENDITURE EQUATIONS**

1. \[ FBT_t = 3138.059 + 0.106GDP_t + 0.667F_{BT,t-1} \]
   \[ (2.935) \quad (2.860) \quad (4.934) \]
   \[ R^2 = .999 \quad D.W. = 1.686 \]

2. \[ RFL_{HOO,t} = 1316.057 + 0.031GDP_t + 0.378RFL_{HOO,t-1} \]
   \[ (3.857) \quad (3.889) \quad (2.197) \]
   \[ R^2 = .998 \quad D.W. = 2.283 \]

3. \[ COPE_t = -591.838 + 0.049PDY_t + 0.501COPE_{t-1} \]
   \[ (-1.477) \quad (2.355) \quad (2.118) \]
   \[ R^2 = .988 \quad D.W. = 1.249 \]

4. \[ FFFHHE_t = 3361.337 + 0.031PDY_t - 3742.365\frac{PFFHHE_t}{P_t} \]
   \[ (5.417) \quad (16.509) \quad (-6.366) \]
   \[ R^2 = .984 \quad D.W. = 1.909 \]

5. \[ SERV_t = 3498.164 + 0.038GDP_t - 2293.702\frac{PSERV_t}{P_t} \]
   \[ (2.038) \quad (10.049) \quad (-1.555) \]
   \[ R^2 = .967 \quad D.W. = 1.797 \]

6. \[ TC_t = 1122.582 + 0.086PDY_t - 2468.667\frac{PTC_t}{P_t} \]
   \[ (1.319) \quad (53.370) \quad (-3.056) \]
   \[ R^2 = .998 \quad D.W. = 2.840 \]

7. \[ RE_t = 770.269 + 0.063GDP_t - 1803.479\frac{PRE_t}{P_t} \]
   \[ (0.767) \quad (58.916) \quad (-1.771) \]
   \[ R^2 = .997 \quad D.W. = 2.631 \]
GOVERNMENT EXPENDITURE EQUATIONS

(8) \[ \text{GADJP}_t = -426.585 + 0.439\text{GREV}_{t-1} + 0.352\text{GADJP}_{t-1} \]
\[ \begin{array}{c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.977 & 3.068 \\
\end{array} \]

(9) \[ \text{GSERV}_t = -321.027 + 0.011\text{GDP}_{t} + 0.759\text{GSERV}_{t-1} \]
\[ \begin{array}{c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.989 & 2.410 \\
\end{array} \]

(10) \[ \text{GTC}_t = 83.626 + 0.908\text{GTC}_{t-1} \]
\[ \begin{array}{c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.960 & 1.711 \\
\end{array} \]

EXPORT EQUATIONS

(11) \[ \text{XRICE}_t = -3397.596 - 0.144\text{XPRICE}_t + 0.402\text{RICE}_{t-1} \]
\[ \begin{array}{c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.634 & 1.708 \\
\end{array} \]

+ 0.792\text{XRICE}_{t-1} - 2786.198\text{D73}_t
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.926 & 2.455 \\
\end{array} \]

(12) \[ \text{XRUB}_t = -195.712 + 0.027\text{XPRUB}_t + 1.414\text{RUB}_t \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.995 & 2.455 \\
\end{array} \]

- 0.380\text{XRUB}_{t-1}
\[ \begin{array}{c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.876 & 1.728 \\
\end{array} \]

(13) \[ \text{XMZE}_t = 228.865 + 1.060\text{MZ}_t + 1.069\text{DPBPZ}_t \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.876 & 1.728 \\
\end{array} \]

- 0.252\text{XMZE}_{t-1}
\[ \begin{array}{c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.876 & 1.728 \\
\end{array} \]

(14) \[ \text{XTAP}_t = -106.297 + 0.405\text{TAP}_t + 0.752\text{XTAP}_{t-1} \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.915 & 1.917 \\
\end{array} \]

(15) \[ \text{XMFG}_t = -1109.251 + 0.146\text{MGDP}_t + 0.268\text{XMFG}_{t-1} \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.962 & 1.451 \\
\end{array} \]

(16) \[ \text{XOTH}_t = -117.471 + 0.015\text{GDP}_{t} + 0.692\text{XOTH}_{t-1} \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.828 & 1.620 \\
\end{array} \]

(17) \[ \text{XSERV}_t = -282.921 + 0.246\text{SERGDP}_t + 0.307\text{XSERV}_{t-1} + 2857.120\text{D66}^* \]
\[ \begin{array}{c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.982 & 2.588 \\
\end{array} \]

\[ \begin{array}{c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.982 & 2.588 \\
\end{array} \]

\[ \begin{array}{c|c|c|c|c}
\text{R}^2 & \text{D.W.} \\
\hline
.982 & 2.588 \\
\end{array} \]
IMPORT EQUATIONS

(18) $IMP_1_t = 11429.275 + 0.026PDY_{t-1} - 8553.100^{M1P_t} (10.478) (3.787) (-6.860)_{PGDP_t}$

(19) $IMP_2_t = 1249.538 + 0.074PDY_t - 3329.708^{M2P_t} (4.568) (29.329) (-9.843)_{PGDP_t}$

(20) $IMP_3_t = -975.649 + 0.038PDY_t (-4.492) (15.807)$

(21) $IMP_4_t = 10927.00 + 0.125PDY_{t-1} - 14124.068^{M4P_t} (8.647) (8.090) (-9.400)_{PGDP_t}$

GROSS FIXED CAPITAL FORMATION EQUATIONS

(22) $AGINV_t = 16.762 + 0.068(GDP_t - GDP_{t-1}) (0.054) (1.886) + 0.124(GDP_{t-1} - GDP_{t-2}) + 0.461AGINV_{t-1} (3.056) (3.023)$

(23) $NAGINV_t = -209.624 + 0.405(GDP_t - GDP_{t-1}) (-0.200) (3.069) + 0.595(GDP_{t-1} - GDP_{t-2}) + 0.732NAGINV_{t-1} (3.777) (11.357)$

OUTPUT EQUATIONS

(24) $CROPOUT_t = -41101.648 + 5.026AGLAB_t (-8.136) (12.780)$

(25) $OTHAG_t = -14095.125 + 1.613AGLAB_t + 1.240AGINV_{t-1} (-6.008) (7.572) (6.268)$

(26) $MGDP_t = -14288.236 + 7.145NAGLAB_t + 0.481MGDP_{t-1} (-2.280) (2.388) (1.935)$

(27) $CONSOUT_t = 21667.660 - 119736.281RNATLAB_t (8.752) (-7.793) + 0.432NAGINV_t (11.344)$
(28) \[ \text{WRTOUT} = -8183.984 + 0.229 \textit{NAGINV}_{t-1} + 6.186 \textit{NAGLAB}_t \]  
\[ (-3.964) \quad (3.020) \quad (6.252) \]  
\[ R^2 = .988 \quad \text{D.W.} = 2.696 \]

(29) \[ \text{SERGDP} = 09364.084 + 61962.344 \textit{RNATLAB}_t \]  
\[ (-3.964) \quad (3.020) \]  
\[ + 0.701 \textit{SERGDP}_{t-1} \]  
\[ (5.145) \]
\[ R^2 = .99 \quad \text{D.W.} = 2.283 \]

(30) \[ \text{TCOUT} = -3335.865 + 2.914 \textit{NAGLAB}_t + 0.022 \textit{NAGINV}_{t-1} \]  
\[ (-5.610) \quad (10.227) \quad (1.026) \]  
\[ R^2 = .992 \quad \text{D.W.} = 1.873 \]

(31) \[ \text{OTHOUT} = -5393.945 + 2.872 \textit{NAGLAB}_t + 0.665 \textit{OTHOUT}_{t-1} \]  
\[ (-1.440) \quad (1.490) \quad (3.381) \]  
\[ + 0.046 \textit{NAGINV}_{t-1} \]  
\[ (1.173) \]  
\[ R^2 = .997 \quad \text{D.W.} = 2.994 \]

**INCOME DISTRIBUTION EQUATIONS**

(32) \[ \text{COMP} = -11929.889 + 2.027 \textit{OTHAG} + 5.372 \textit{NAGLAB}_t \]  
\[ (-5.875) \quad (4.780) \quad (3.397) \]  
\[ R^2 = .985 \quad \text{D.W.} = 1.104 \]

(33) \[ \text{FY} = 537442.000 - 2.761 \textit{OTHAG} - 617994.627 \textit{RAGTLAB}_t \]  
\[ (7.078) \quad (3.679) \quad (7.047) \]  
\[ - 0.862 \textit{XRICE}_t \]  
\[ (-1.881) \]  
\[ R^2 = .943 \quad \text{D.W.} = 1.808 \]

(34) \[ \text{YUE} = 29541.813 + 0.569 \textit{GDP} - 17.337 \textit{NAGLAB}_t \]  
\[ (2.302) \quad (3.190) \quad (-1.896) \]  
\[ R^2 = .972 \quad \text{D.W.} = 1.927 \]

(35) \[ \text{YPROP} = -111036.547 + 0.711 \textit{MGDP} + 135660.782 \textit{RAGTLAB}_t \]  
\[ (-3.381) \quad (7.473) \quad (3.443) \]  
\[ R^2 = .988 \quad \text{D.W.} = 2.489 \]

(36) \[ \text{IDTAX} = -76.798 + 0.115 \textit{GDP}_t \]  
\[ (-0.098) \quad (16.082) \]  
\[ R^2 = .955 \quad \text{D.W.} = 1.755 \]

**IDENTITIES**

(37) \[ \text{TPCE} = \text{FBT}_t + \text{RFLHHO}_t + \text{COPE}_t + \text{FFHHE}_t + \text{SERV}_t + \text{TC}_t + \text{RE}_t \]

(38) \[ \text{TGCE} = \text{GADJP}_t + \text{GSERV}_t + \text{GTC}_t \]

(39) \[ \text{TX} = \text{XRICE}_t + \text{XRUB}_t + \text{XMZE}_t + \text{XTAP}_t + \text{XMFG}_t + \text{XOTH}_t + \text{XSERV}_t \]

(40) \[ \text{TIMP} = \text{IMP1}_t + \text{IMP2}_t + \text{IMP3}_t + \text{IMP4}_t + \text{IMP5}_t + \text{IMPSERV}_t \]
(41) \[ TINV_{t} = AGINV_{t} + NAGINV_{t} + DINV_{t} \]

(42) \[ TYUE_{t} = FY_{t} + YUE_{t} \]

(43) \[ 2GDP_{t} = TPCE_{t} + TGCE_{t} + TX_{t} - TIMP_{t} + SD_{t} + TINV_{t} + CROPOUT_{t} + \]
\[ OTHAG_{t} + MGDP_{t} + CONSORT_{t} + WRTOUT_{t} + SERGDP_{t} + TCOUT_{t} + \]
\[ OTHOUT_{t} \]

(44) \[ 2NY_{t} = GDP_{t} + NFYPROW_{t} - IDTAX_{t} - CCA_{t} + COMP_{t} + TYUE_{t} + YPROP_{t} + \]
\[ CORPSAV_{t} + DTCORP_{t} + GGY_{t} - INTPD_{t} - INTCD_{t} \]

(45) \[ PDY_{t} = NY_{t} - DTHH_{t} + TRANIN_{t} - TRANOUT_{t} \]
LIST OF VARIABLES

(Note: All variables are in millions of baht, 1962 prices, unless otherwise noted.)

(1) AGINV = Fixed Capital Formation in Agriculture
(2) AGLAB = Number of Workers in Agriculture (1,000's of workers)
(3) CCA = Capital Consumption Allowance
(4) COMP = Compensation of Employees
(5) CONSOUT = Construction Output
(6) COPE = Consumption of Clothing and Other Personal Effects
(7) CORPSAV = Saving of Corporations and Government Enterprises
(8) CROPOUT = Crop Output
(9) D66* Dummy Variable, 1962-65 = 0; 1966-1974 = 1
(10) D73 = Dummy Variable, 1973 = 1; all other years = 0
(11) DINV = Change in Inventories
(12) DTCP = Direct Taxes on Corporations
(13) DTHH = Direct Taxes on Households
(14) DXPBPMZ = Difference Between Export Price and Bangkok Wholesale Price of Maize (number of baht)
(15) FBT = Consumption of Food, Beverages, and Tobacco
(16) FFHHE = Consumption of Furniture, Furnishings, and Household Equipment
(17) FY = Farm Income
(18) GADJP = Government Expenditures on Administration, Defense, Justice and Police
(19) GDP = Gross Domestic Product
(20) GGY = General Government Income From Property and Entrepreneurship

(21) GREV = Government Revenue

(22) GSERV = Government Expenditures on Services

(23) GTC = Government Expenditures on Transportation and Communication

(24) IDTAX = Indirect Taxes

(25) IMP1 = Imports of Consumer Goods, Passenger Cars and Tires

(26) IMP2 = Imports of Intermediate Goods (Chiefly for Consumer Goods),
    Chassis and Bodies, and Fertilizers and Pesticides

(27) IMP3 = Imports of Fuel and Lubricants

(28) IMP4 = Imports of Capital Goods (not including Fertilizers and
    Pesticides), Buses and Trucks, and Intermediate Goods
    (Chiefly for Capital Goods)

(29) IMP5 = Total Merchandise Imports in Balance of Payments—(IMP1 +
    IMP2 + IMP3 + IMP4)

(30) IMPSERV = Imports of Services

(31) INTCD = Interest on Consumer Debt

(32) INTPD = Interest on Public Debt

(33) M1P/PGDP = Ratio of Price Deflator for IMP1 to the GDP Price Deflator

(34) M2P/PGDP = Ratio of Price Deflator for IMP2 to the GDP Price Deflator

(35) M4P/PGDP = Ratio of Price Deflator for IMP4 to the GDP Price Deflator

(36) MGDPO = Manufacturing Output

(37) MZE = Output of Maize

(38) NAGLAB = Number of Workers in Nonagriculture (1,000's of workers)

(39) NAGINV = Fixed Capital Formation on Nonagriculture
(40) NFYPROW = Net Factor Income Payment from the Rest of the World
(41) NY = National Income
(42) OTHAG = Output of Agricultural Products, other than Crops
(43) OTHOUT = Output of other Products
(44) PDY = Personal Disposable Income
(45) PFFHHE/P = Ratio of Price Deflator for FFHHE to the Price Deflator for All Consumption
(46) PRE/P = Ratio of Price Deflator for RE to the Price Deflator for All Consumption
(47) PSERV/P = Ratio of Price Deflator for SERV to the Price Deflator for All Consumption
(48) PTC/P = Ratio of Price Deflator for TC to the Price Deflator for All Consumption
(49) RAGTLAB = Ratio of Agricultural Labor to Total Labor Force
(50) RE = Consumption Expenditures on Recreation and Entertainment
(51) RFLHHO = Consumption Expenditures on Rent, Fuel, Light, and Household Operation
(52) RICE = Output of Rice
(53) RNATLAB = Ratio of Nonagricultural Labor to Total Labor Force
(54) RUB = Output of Rubber
(55) SD = Statistical Discrepancy
(56) SERGDP = Output of Services
(57) SERV = Consumption Expenditures on Services
(58) TAP = Output of Tapioca
(59) TC = Consumption Expenditures of Transportation and Communication
(60) TCOUT = Output of Transportation and Communication
(61) TGCE = Total Government Consumption Expenditures
(62) TIMP = Total Imports
(63) TINV = Total Fixed Capital Formation
(64) TPCE = Total Personal Consumption Expenditures
(65) TRANIN = Net Transfers to Households from Government and ROW
(66) TRANOUT = Net Transfers From Households to Government and ROW
(67) TX = Total Exports
(68) TYUE = Total Income for Unincorporated Enterprises
(69) WRTOUT = Output of Wholesale and Retail Trade
(70) XMFG = Exports of Manufactured Goods
(71) XMZE = Exports of Maize
(72) XOTH = Exports of Other Goods
(73) XPRICE = Export Price of Rice (Baht per Metric Ton)
(74) XPRUB = Export Price of Rubber (Baht per Metric Ton)
(75) XRICE = Exports of Rice
(76) XRUB = Exports of Rubber
(77) XSERV = Exports of Services
(78) XTAP = Exports of Tapioca
(79) YPROP = Income from Property
(80) YUE = Income from Unincorporated Enterprises Other than Farms
C. Discussion of Equation Specification

1. Private Personal Consumption Equations

The equations in this sector have two general patterns. First, to as great an extent as possible in this sector as in other sectors, we have tried to include the effect of prices on the endogenous variables. In some cases a specification with a significant price effect was selected rather than one which might have predicted better. This is because, with the inclusion of a monetary sector which explains prices, the direct effect of monetary policy on the endogenous variables can be measured. Where a price effect is found to be unimportant, the specification of the consumption equations follows that of the permanent income hypothesis, where the lagged value of the consumption variable captures the permanent income effect.

2. Government Expenditure Equations

Here is a sector where one would prefer a much more disaggregated set of data to capture the differential effects of government spending more successfully. In any event, there does not seem to be a great deal of discretionary anti-cyclical fiscal policy with respect to government expenditures in Thailand. Therefore, the pattern of government expenditures follows a fairly smooth upward trend in response to the growth of the economy, reflected in the income variables, and to the growth of the population, reflected in the lagged values of the endogenous variable.
3. Export Equations

The volume of exports for a particular country is difficult to capture in just one equation because the volume of any commodity that is exported in a year depends on both domestic and international economic conditions. More desirable would be to have a structural model for each commodity that would model world demands and supplies and thereby world prices. Models of this sort constitute a very major research effort in themselves, so this approach becomes infeasible at this point. Any sort of single equation expression of the exports of an economy really is a reduced form equation in its own right. It reflects a series of equilibrium positions over the time period with the amount exported being a function of many demand and supply factors that are not explicitly specified or modeled. Because of this, it is difficult a priori even to say whether a single equation will be primarily a demand function, expressing world demand for Thai exports, or primarily a supply function, expressing Thai production reaction, say, to the world export price that it faces.

This is a familiar problem in statistical time series demand analysis in determining whether or not a set of price-quantity points reflect primarily a demand curve, primarily a supply curve, or some combination of shifts in the demand and supply curves. If we have a complete structural model with all equations identified, then it is possible to define the demand and supply functions explicitly. Working only with reduced form equations, as we are doing here, it is difficult, if not impossible, to do
this. Therefore, given the nature of the product being exported and the place that a country plays in the world market for this commodity, a single equation approach may show a strongly negative price effect, which would indicate that the equation is basically a demand relationship. Alternatively, we may observe a strongly positive price effect, indicating a supply relationship, or finally, no significant price effect at all, indicating, possibly, simultaneous demand and supply shifts.

Therefore, the export equations that are presented in Model I should be considered in this light. They really constitute reduced form equations of underlying structural models, and therefore, do not describe the underlying structure in the international market for these commodities. In the context of a macro-econometric model, they do constitute structural equations in the sense of explaining (and forecasting) the monetary value of the exports of a particular commodity on the basis of the exogenous and other endogenous variables of the model.

Specifically, we observe in the rice export equation a negative export price effect that would seem to indicate primarily a demand relationship for Thai rice. In the rubber export equation, we observe a positive price effect, indicating primarily a supply relationship. For maize, where the price variable is the difference between the export price of maize and the Bangkok Wholesale Price, we observe a positive effect, again indicating a supply relationship. For tapioca, manufactured goods, services, and other (a residual category), no significant price effect is observed.
With respect to the above discussion, it is argued that these apparently contradictory results are plausible from an economic theory point of view.

Aside from the price effects, we see that the primary explanatory variables are output variables and lagged values of exports, indicating evidence of trend in the export of the various commodity groups. Also, in the equations for rice and services we have included dummy variables to capture what we consider to be either a discrete shift in the intercept of the regression equation or a condition which does not reflect the basic economic conditions in the market we are trying to describe. In the rice export equation, the dummy variable, D73, is introduced to reflect the placing of an export quota on rice for 1973. In the service export equation, the dummy variable, D66*, is introduced to show an intercept shift resulting from the large-scale introduction of U.S. troops into Thailand during the Vietnam War.

4. Import Equations

Because import equations have many of the same characteristics as consumption expenditure equations, many of the same considerations apply as discussed above. In three of the four import groups we see a strong price effect on the level of imports.

It is noted that the classification of imports used is that of NESDB. There are perhaps other breakdowns and aggregations of imports that might be used, which might be more economically interesting if one were to expand this sector. But, as mentioned above, wherever it seemed appropriate the data classifications were selected to coincide with the national income data employed and published by NESDB.
5. Gross Fixed Capital Formation Equations

The specification of these investment equations follows a standard accelerator formulation in explaining levels of investment in terms of past changes in output or GDP. The level of aggregation in these equations, i.e., agricultural investment and nonagricultural investment, is perhaps excessive but was chosen only because of data availability. New, more disaggregated data, by industry group is now available but only for the period beginning in 1967. Because we wished to simulate Model I for the 1962-1974 period using actual data, the more aggregated equations were used in this model. In Model II, as will be discussed in Section III, using the disaggregated investment data, we "forecast" these data back to 1962. Then we used these data in disaggregating the investment sector and in generating capital stock series for the output equations. (See Section B of the Data Appendix for a detailed description of this process.)

6. Output Equations

In most macroeconometric models the general form of the output equations is that of an aggregate production function, i.e., Output = f (Capital, Labor). It is difficult to use this form of function in Thailand because of the lack of any capital stock or capital services time series data. As mentioned above, only investment data are available. Therefore the equations that appear are not really aggregate production functions in the strictest sense of the term; they are regression equations that attempt to predict the monetary value of output for the various output groups.
One possible approach, which uses only investment data and which preserves in part the production function nature of the relationship, is to employ a transformation of the following sort, which was used by Dr. Chinnawoot Soonthornsima in his Ph.D. dissertation at the University of Michigan.

This assumes that the effect of capital stock on real output takes place in one year, i.e., \( k_{t-1} = k_{t-2} + i_{t-1} \) where \( i = \) investment

\[
y_t = f (k_{t-2} + i_{t-1})
\]

But \( y_{t-1} = f (k_{t-2}) \)

\[
k_{t-2} = \phi (y_{t-1}) \quad \text{where } \phi = f^{-1}
\]

So that \( y_t = f(\phi (y_{t-1}) + i_{t-1}) \)

or \( y_t = f(y_{t-1}, i_{t-1}) \)

With the addition of some labor variable, the general form of the output equations investigated then becomes

\[
\text{Output}_t = (\text{Labor}_t, \text{Investment}_{t-1}, \text{Output}_{t-1})
\]

and the choice of which of these variables that appears in each equation was determined on the criterion of statistical significance.

The use of disaggregated investment data discussed before would be quite desirable in these equations. Again, however, in order to use the longer sample period, 1962-1974, for simulation purposes, we restricted our investment data in Model I to the level of aggregation of agricultural and nonagricultural investment. In Model II, we use the "estimated" capital stock data.
7. Income Distribution Equations

The degree of disaggregation is most unsatisfactory in this group of equations. To capture the effects of the interactions between the agricultural and nonagricultural sector in terms of income variables, it would be most desirable to have a much more detailed breakdown into ag and nonag income. Generating such data and expanding this sector will be one of the most important priorities in future model generations.

D. Results of a Reduced Form Simulation of Model I

As discussed in Section I.B.2, our structural model is written as

\[ BY + GZ = U, \]

and by rewriting the model as

\[ Y = -B^{-1}GZ + B^{-1}U \]

\[ = \pi Z + V, \]

we obtain the reduced form of the model, where the jointly dependent variables \( Y \) are expressed as a function of the predetermined variables \( Z \). Once the matrices of structural coefficients are obtained, the matrix of reduced form coefficients, \( \pi \), may be calculated. Multiplying \( \pi \) by \( Z \), the matrix of predetermined variables, we obtain predictions of each of the jointly dependent variables, which can then be compared with the actual values of these variables to evaluate the predictive capability of the entire structural model.

There are two possible ways this can be done. We note that the list of predetermined variables includes two kinds of variables; 1) exogenous variables, and 2) lagged values of the jointly dependent variables. In the first approach, we use the actual values of the lagged jointly dependent
(endogenous) variables. In the second, the value for each of the endogenous variables is calculated for the first observation, 1962. Then, wherever lagged values of the endogenous variables appear, say, for 1963, the calculated 1962 values are used, and so on for the rest of the simulation period. This second method is a much more stringent one for evaluating the model because it reflects the dynamic stability of the model. For example, if the predictions of the endogenous variables are poor in the early years, in a dynamically unstable model, the errors will tend to cumulated in the later years, and the predictions in these later years will tend to be very large. If the model is dynamically stable, these errors will be offset in other equations and predictions in the later years will not tend to wander off.

In Table 1 we present the results of the simulation of Model I. For each of the jointly dependent variables we show the actual value of the variable, denoted by the superscript A, the forecast value of the variable using the actual values of the lagged endogenous variables, denoted by the superscript * and the forecast values of the variable, using the calculated values of the endogenous variables, denoted by the superscript **.

\[
U = \frac{\sqrt{\sum (\text{Predicted}_t - \text{Actual}_t)^2}}{\sqrt{\sum \text{Predicted}_t^2} \sqrt{\sum \text{Actual}_t^2}}
\]

This statistic is a measure of the accuracy of the forecast, and is approximately the average percent error of forecast.
In general, we see that the U-Statistic is higher, as would be expected, for the forecast series using the calculated values of the lagged endogenous variables, though this is not universally true. For both cases the forecasts seem to follow the actual values fairly, successfully as reflected in the U-Statistics. Two exceptions to this are those of Agricultural Investment and Construction Output, using the calculated values of the lagged endogenous variables, which indicate some dynamic instability in these equations. For the case where the actual value of the lagged endogenous variables is used, the U-Statistics range from 0.003 to 0.064 indicating forecasts that are close to the actual values.

As stated in the Introduction, Model I is designed specifically to be linear in both parameters and variables to describe the real sector of the Thai economy. We argue that, in terms of explaining and forecasting the monetary levels of aggregate economic variables, it is a fairly effective model. In Section III we present a modified version of Model I that allows for nonlinearities in the variables, which disaggregates Model I further and introduces explicitly a monetary and price sector.
### TABLE 1

Actual and Forecast Values of Endogenous Variables from Reduced Form Analysis

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<th>Year</th>
<th>FB touted</th>
<th>FB t</th>
<th>FB t</th>
<th>RFLH O touted</th>
<th>RFLH O t</th>
<th>RFLH O t</th>
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**TABLE 1 (Cont'd)**
III. MODEL II: A MACROECONOMETRIC MODEL LINEAR IN PARAMETERS AND NONLINEAR IN VARIABLES

A. Specification of the Equations in Model II

Model II is a 55-equation model, that remains linear in the parameters but allows for nonlinearities in the variables. It varies from Model I in the following ways:

1) the private consumption expenditure equations are now specified in per capita figures rather than in levels;
2) three of the four import equations are specified in per capita terms rather than in levels;
3) the gross fixed capital formation equations have been disaggregated from two to seven equations;
4) six of the seven output equations are specified in a modified Cobb-Douglas production function form and the seventh in an output per worker form;
5) a fairly simple monetary and price sector has been added to monetize the model and to capture the effects of changes on the real sectors of the model.

The government expenditure, export, and income distribution equations remain unchanged from Model I.

The reason for changing from looking at levels for the cases of private consumption expenditures and for three of the import equations is that per capita consumption (and also imports) provides a better measure of the welfare of the people in the economy than does just consumption
level. Obviously, we can observe the levels of consumption increasing but if population is rising faster, we will observe a net decrease in per capita consumption. Therefore, if the level of consumption goods obtainable by each person in the economy is used as a welfare measure, as it often is, per capita consumption is preferable as the dependent variable in these equations. The reason for remaining with the level in the case of IMPl is simply that a satisfactory specification for this import group was not found. Trying to do so remains an area for future research.

Note that in general, as might be expected, the goodness-of-fit statistics for the per capita specifications in Model II are a bit worse than those for the level case in Model I. Nevertheless, they remain strong, and so, given the additional economic content of the per capita specification, this specification is retained in Model II.

The Gross Fixed Capital Formation Equation Sector has been disaggregated from 2 to 7 equations, reflecting the same level of industry origin disaggregation as appears in the output equations. To achieve this degree of disaggregation, it was necessary to take the NESDB disaggregated data for the period 1967-1974, and estimate the 1961-1966 figures. The estimation method used here is described in detail in Section B of the Data Appendix. Of course the results in this sector must be considered in light of the fact that this data estimation has been carried out, but we assert that the estimation process is a reasonable one and that the benefits gained from the additional disaggregation merit this approach. The reader must judge for himself if this is true, but one further
thing to keep in mind is that the 1967-1974 data are "hard" data, and since we are interested in using the model for forecasting the period after 1974, the forecast will be based for the most part on this "hard" data in the latter years of the sample period.

The output equations have been respecified in a modified Cobb-Douglas form. Our original intention was to specify an unrestricted Cobb-Douglas form, but as often happens in estimating time-series production functions, the multicollinearity between the labor and capital series makes the estimated elasticities very unreliable. In fact, in almost all cases the capital coefficient turns significantly negative, which is an unacceptable result. Therefore, we decided to fit a general functional form of $\ln(\frac{Output}{Labor}) = f(\ln \text{Capital})$. This specification assumes that the elasticity of labor is unity, which is no doubt an excessive restriction, but it does allow us to get an unrestricted estimate of the capital elasticity. It also allows us to generate multipliers for labor in the various industry groups. Multipliers such as these can have important policy implications for programs of moving labor from one industry to another on overall GDP and other endogenous variables of the system.

This specification was used in six of the seven industry groups, the exception being that of Construction Output. This industry group exhibits the unusual characteristic that output per worker increases through 1968 and then declines very sharply. With an increasing capital stock, this leads to a negative sign for capital in construction. Why output per worker should be declining is not easy to explain, but it certainly asks for further analysis of this sector. Note also that the
D-W Statistics for some of these productions are unacceptably low. This also suggests further research in the whole output sector.

Finally, a rather rudimentary monetary and price sector has been added to Model II. The monetary sector in Thailand is a very difficult sector to model on the basis of traditional macro theory for a couple of reasons. First, the bulk of the money supply is held in currency and not in Demand Deposits. Second, the historical pattern of interest rates has been one of rigidity. Therefore, any sort of interest rate monetary mechanism is extremely hard to capture, and the traditional concept of monetary policy working through commercial bank reserves and thereby through demand deposit creation is very much weakened.

Therefore, we concentrated on the determination of M1, the narrowly defined money supply, and on the determination of the GDP and the Consumption Price Indexes (the latter not being the published Consumer Price Index). The effects of these price indexes feed back through the model through the consumption and import equations. One interesting result here is the very strong effect of the Import Price Index of Fuel & Lubricants on domestic price levels.

In summary, Model II is very similar in overall structure to that of Model I, but the additional flexibility of allowing nonlinearity in the variables allows us to ask some further economic questions in terms of the effects of particular variables. As will be seen, the simulation results of Model II remain very good, which is a very positive result, given the greater complexity and flexibility of this second model.
### THE EQUATIONS OF MODEL II

#### PRIVATE CONSUMPTION EXPENDITURE EQUATIONS

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<td>(7)</td>
<td>( \frac{\text{RE}_t}{N_t} = -14.220 + 0.069 \frac{\text{GDP}_t}{N_t} - 37.394 \frac{\text{PRE}_t}{P_t} )</td>
<td>((-0.453)(35.427)(-1.157))</td>
<td></td>
<td>(-1.157)</td>
<td>(-1.157)</td>
<td>.992</td>
<td>2.613</td>
</tr>
</tbody>
</table>

#### GOVERNMENT CONSUMPTION EQUATIONS

<table>
<thead>
<tr>
<th>Equation</th>
<th>Expenditure</th>
<th>Coefficients</th>
<th>t-stat</th>
<th>Coefficients</th>
<th>t-stat</th>
<th>R²</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8)</td>
<td>( \text{GADJP}<em>t = -426.585 + 0.439 \text{GREV}</em>{t-1} + 0.352 \text{GADJP}_{t-1} )</td>
<td>((-0.842)(3.291)(1.848))</td>
<td></td>
<td></td>
<td></td>
<td>.977</td>
<td>3.068</td>
</tr>
<tr>
<td>(9)</td>
<td>( \text{GSERV}_t = -321.027 + 0.011 \text{GDP}<em>t + 0.759 \text{GSERV}</em>{t-1} )</td>
<td>((-2.400)(2.649)(5.416))</td>
<td></td>
<td></td>
<td></td>
<td>.989</td>
<td>2.410</td>
</tr>
<tr>
<td>(10)</td>
<td>( \text{GTC}<em>t = 83.626 + 0.908 \text{GTC}</em>{t-1} )</td>
<td>((3.110)(17.079))</td>
<td></td>
<td></td>
<td></td>
<td>.960</td>
<td>1.711</td>
</tr>
</tbody>
</table>
EXPORT EQUATIONS

(11)  \[ XRICE_t = -3397.596 - 0.144 XPRICE_t + 0.402 RICE_{t-1} \]
      \[ + 0.792 XRICE_{t-1} - 2786.198 D73_t \]
      \[ (1.574)(-1.403) \]
      \[ (3.064) \]
      \[ R^2 = .634 \quad D.W. = 1.708 \]

(12)  \[ XRUB_t = -195.712 + 0.027 XPRUB_t + 1.414 RUB_{t-1} \]
      \[ - .380 XRUB_{t-1} \]
      \[ (2.397)(3.662) \]
      \[ (18.543) \]
      \[ R^2 = .995 \quad D.W. = 2.455 \]

(13)  \[ XMZE_t = 228.865 + 1.060 MZE_{t-1} + 1.069 DXPBPZ_t \]
      \[ - 0.252 XMZE_{t-1} \]
      \[ (1.373) \]
      \[ (6.286) \]
      \[ (16.68) \]
      \[ R^2 = .876 \quad D.W. = 1.728 \]

(14)  \[ XTAP_t = -106.297 + 0.405 TAP_t + 0.752 XTAP_{t-1} \]
      \[ (0.897) \]
      \[ (2.718) \]
      \[ (3.90) \]
      \[ R^2 = .915 \quad D.W. = 1.917 \]

(15)  \[ XMFG_t = -1109.251 + 0.146 MGDP_t + 0.268 XMFG_{t-1} \]
      \[ (2.472) \]
      \[ (3.188) \]
      \[ (1.074) \]
      \[ R^2 = .962 \quad D.W. = 1.451 \]

(16)  \[ XOTH_t = -117.471 + 0.015 GDP_{t-1} + 0.692 XOTH_{t-1} \]
      \[ (0.224) \]
      \[ (1.745) \]
      \[ (2.802) \]
      \[ R^2 = .828 \quad D.W. = 1.620 \]

(17)  \[ XSERV_t = -282.921 + 0.246 SERGDP_t + 0.307 XSERV_{t-1} \]
      \[ + 2857.120 D666_t \]
      \[ (0.471) \]
      \[ (2.308) \]
      \[ (2.171) \]
      \[ R^2 = .982 \quad D.W. = 2.588 \]

IMPORT EQUATIONS

(18)  \[ IMP1_t = 11429.275 + 0.026 PDY_{t-1} - 8553.100 \frac{M1P_t}{PGDP_t} \]
      \[ (10.478) \]
      \[ (3.787) \]
      \[ (6.860) \]
      \[ R^2 = .792 \quad D.W. = 2.284 \]

(19)  \[ \frac{IMP2_t}{N_t} = -19.7 + .0909 \frac{PDY_t}{N_t} - 82.000 \frac{M2P_t}{PGDP_t} \]
      \[ (-1.755)(17.586) \]
      \[ (-8.024) \]
      \[ R^2 = .966 \quad D.W. = 2.336 \]

(20)  \[ \frac{IMP3_t}{N_t} = -51.100 + 0.0471 \frac{PDY_t}{N_t} \]
      \[ (-3.936) \]
      \[ (9.327) \]
      \[ R^2 = .887 \quad D.W. = 1.937 \]

(21)  \[ \frac{IMP4_t}{N_t} = 241.400 + 0.1556 \frac{PDY_{t-1}}{N_{t-1}} - 400.000 \frac{M4P_t}{PGDP_t} \]
      \[ (6.029) \]
      \[ (6.996) \]
      \[ (9.139) \]
      \[ R^2 = .967 \quad D.W. = 1.624 \]
      \[ + 0.1629 \frac{IMP4_{t-1}}{N_{t-1}} \]
GROSS FIXED CAPITAL FORMATION EQUATIONS

(22) \( AGINV_t = 126.607 + 0.071 (GDP_t - GDP_{t-1}) \)  
\( + 0.114 (GDP_{t-1} - GDP_{t-2}) + 0.451 \ AGINV_{t-1} \)  
\( (0.464) (2.707) \)

(23) \( MANINV_t = -589.457 + 0.073 (GDP_t - GDP_{t-1}) \)  
\( + 0.130 (GDP_{t-1} - GDP_{t-2}) + 0.872 \ MANINV_{t-1} \)  
\( (-1.603) (2.167) \)

(24) \( CONSINV_t = -75.999 + 0.035 (GDP_t - GDP_{t-1}) \)  
\( + 0.056 (GDP_{t-1} - GDP_{t-2}) + 0.575 \ CONSINV_{t-1} \)  
\( (-0.578) (2.397) \)

(25) \( TCINV_t = 749.259 + 0.087 (GDP_t - GDP_{t-1}) \)  
\( + 0.744 \ TCINV_{t-1} \)  
\( (1.751) (2.060) \)

(26) \( WRTINV_t = 386.916 + 0.118 (WRTOUT_t - WRTOUT_{t-1}) \)  
\( + 0.208 (WRTOUT_{t-1} - WRTOUT_{t-2}) + 0.770 \ WRTINV_{t-1} \)  
\( (1.840) (1.707) \)

(27) \( SERVINV_t = -156.963 + 0.046 (GDP_t - GDP_{t-1}) \)  
\( + 0.088 (GDP_{t-1} - GDP_{t-2}) + 0.746 \ SERVINV_{t-1} \)  
\( (-0.434) (1.281) \)

(28) \( OTHINV_t = 184.627 + 0.087 (GDP_t - GDP_{t-1}) \)  
\( + 0.228 (GDP_{t-1} - GDP_{t-2}) + 0.679 \ OTHINV_{t-1} \)  
\( (0.372) (1.555) \)

OUTPUT EQUATIONS

(29) \( \ln \left( \frac{AGOUT_t}{AGLAB_t} \right) = 3.385 + 0.427 \ln KAG_t \)  
\( (10.559)(13.872) \)

(30) \( \ln \left( \frac{MGDP_t}{MANLAB_t} \right) = 3.606 + 0.644 \ln KMAn_t \)  
\( (13.258)(24.244) \)
(31) \[
\frac{\text{CONSOUT}_t}{\text{CONLAB}_t} = \frac{19780.387 - 0.726 \ K_{\text{CONS}}}{(2.141)(-2.896)}
\]
\[
+ 0.779 \frac{\text{CONSOUT}_{t-1}}{\text{CONLAB}_{t-1}} (5.331)
\]
\[
\hat{R}^2 = 0.908 \quad \text{D.W.} = 1.030
\]

(32) \[
\ln \left( \frac{\text{WRTOUT}_t}{\text{WRTLAB}_t} \right) = -1.329 + 1.059 \ln \text{KWRT}_t (-2.146)(18.164)
\]
\[
\hat{R}^2 = 0.965 \quad \text{D.W.} = 0.904
\]

(33) \[
\ln \left( \frac{\text{SERGDP}_t}{\text{SERLAB}_t} \right) = 6.441 + 0.266 \ln \text{KSERV}_t (41.185)(17.378)
\]
\[
\hat{R}^2 = 0.962 \quad \text{D.W.} = 0.553
\]

(34) \[
\ln \left( \frac{\text{TCOUT}_t}{\text{TCLAB}_t} \right) = 6.726 + 0.318 \ln \text{KTC}_t (24.977)(13.148)
\]
\[
\hat{R}^2 = 0.935 \quad \text{D.W.} = 2.110
\]

(35) \[
\ln \left( \frac{\text{OTHOUT}_t}{\text{OTHLAB}_t} \right) = 3.162 + 0.616 \ln \text{KOTH}_t (11.266)(25.007)
\]
\[
\hat{R}^2 = 0.981 \quad \text{D.W.} = 0.718
\]

**INCOME DISTRIBUTION EQUATIONS**

(36) \[
\text{COMP}_t = -11929.889 + 2.027 \ OTHAG_t + 5.372 \ NAGLAB_t (-5.875) (4.780) (3.397)
\]
\[
\hat{R}^2 = 0.985 \quad \text{D.W.} = 1.104
\]

(37) \[
\text{FY}_t = 537442.001 - 2.761 \ OTHAG_t - 617994.000 \ RAGTLAB_t (7.078)(-3.679) (-7.047)
\]
\[
- 0.862 \ \text{XRICE}_t (-1.881)
\]
\[
\hat{R}^2 = 0.943 \quad \text{D.W.} = 1.808
\]

(38) \[
\text{YUE}_t = 29541.813 + 0.569 \ \text{GDP}_t - 17.337 \ NAGLAB_t (2.302) (3.190) (-1.896)
\]
\[
\hat{R}^2 = 0.972 \quad \text{D.W.} = 1.927
\]

(39) \[
\text{YPROP}_t = -111036.547 + 0.711 \ MGDP_t + 135660.782 \ RAGTLAB_t (-3.381) (7.473) (3.443)
\]
\[
\hat{R}^2 = 0.988 \quad \text{D.W.} = 2.489
\]

(40) \[
\text{IDTAX}_t = -76.798 + 0.115 \ \text{GDP}_t (-0.098)(16.082)
\]
\[
\hat{R}^2 = 0.955 \quad \text{D.W.} = 1.755
\]

**MONETARY AND PRICE EQUATIONS**

(41) \[
\text{CHP}_t = 2057.450 + 0.073 \ \text{GDPCP}_t (4.404)(21.992)
\]
\[
\hat{R}^2 = 0.976 \quad \text{D.W.} = 1.314
\]

(42) \[
\text{DDHP}_t = 1162.477 + 0.067 \ \text{XNAGCP}_t (3.037)(16.696)
\]
\[
\hat{R}^2 = 0.959 \quad \text{D.W.} = 0.962
\]
\[ TDHp_t = -12844.045 + 0.238 \text{ GDPCP}_t \]
\[ (43) \]
\[ \text{R}^2 = .973 \quad \text{D.W.} = 0.940 \]

\[ PGdp_t = 0.676 + 0.000018 \text{ M1}_t + 0.141 \text{ M3P}_t \]
\[ (44) \]
\[ \text{R}^2 = .969 \quad \text{D.W.} = 1.738 \]

\[ P_t = 0.423 + 0.00001 \text{ M1}_t + 0.408 \text{ PGDP}_t \]
\[ + 0.068 \text{ M3P}_t \]
\[ (45) \]
\[ \text{R}^2 = .990 \quad \text{D.W.} = 1.812 \]

**IDENTITIES**

\[ \text{TPCE}_t = \frac{\text{FBT}_t}{N_t} + \frac{\text{RFLHHO}_t}{N_t} + \frac{\text{COPE}_t}{N_t} + \frac{\text{FFHHE}_t}{N_t} + \frac{\text{SERV}_t}{N_t} + \frac{\text{TC}_t}{N_t} + \frac{\text{RE}_t}{N_t} \]
\[ (46) \]

\[ \text{TGCE}_t = \text{GADJP}_t + \text{GSERV}_t + \text{GTC}_t \]
\[ (47) \]

\[ \text{TX}_t = \text{XRICE}_t + \text{XRUB}_t + \text{XMZE}_t + \text{XTAP}_t + \text{XMGF}_t + \text{XOTH}_t + \text{XSERV}_t \]
\[ (48) \]

\[ \text{TIMP}_t = \text{IMP1}_t + \frac{\text{IMP2}_t}{N_t} + \frac{\text{IMP3}_t}{N_t} + \frac{\text{IMP4}_t}{N_t} + \frac{\text{IMP5}_t}{N_t} + \frac{\text{IMPSERV}_t}{N_t} \]
\[ (49) \]

\[ \text{TINV}_t = \text{AGINV}_t + \text{MANINV}_t + \text{CONSINV}_t + \text{TCINV}_t + \text{WRTINV}_t + \text{SERINV}_t + \text{OTHINV}_t + \text{DINV}_t \]
\[ (50) \]

\[ \text{TYUE}_t = \text{FY}_t + \text{YUE}_t \]
\[ (51) \]

\[ \text{M1}_t = \text{CHP}_t + \text{DDHP}_t \]
\[ (52) \]

\[ 2GDP_t = \text{TPCE}_t + \text{TGCE}_t + \text{TX}_t - \text{TIMP}_t + \text{TINV}_t + \text{SD}_t + \text{AGOUT}_t + \text{MCDP}_t + \text{CONSOUT}_t + \text{WRTOUT}_t + \text{SERGDP}_t + \text{TCOUT}_t + \text{OTHOUT}_t \]
\[ (53) \]

\[ 2NY = \text{GDP}_t + \text{NFYPROW}_t - \text{IDTAX}_t - \text{CCA}_t + \text{COMP}_t + \text{TYUE}_t + \text{YROP}_t + \text{CORPSAV}_t + \text{DTCP}_t + \text{GGY}_t - \text{INTPD}_t - \text{INTCD}_t \]
\[ (54) \]

\[ PDY_t = \text{NY}_t - \text{DTHH}_t + \text{TRANIN}_t - \text{TRANOUT}_t \]
\[ (55) \]
LIST OF VARIABLES IN MODEL II, NOT IN MODEL I

(1) AGOUT = Total Output in Agriculture

(2) CHP = Currency in Hands of the Public

(3) CONLAB = Workers in Construction (millions of workers)

(4) CONSINV = Gross Fixed Capital Formation in Construction

(5) DDH = Demand Deposits in Hands of the Public

(6) GDPCP = Gross Domestic Product in Current Prices

(7) KAG = Capital Stock in Agriculture

(8) KCONS = Capital Stock in Construction

(9) KMAN = Capital Stock in Manufacturing

(10) KOTH = Capital Stock in Other

(11) KSERV = Capital Stock in Services

(12) KTC = Capital Stock in Transportation and Communication

(13) KWRT = Capital Stock in Wholesale and Retail Trade

(14) M3P = Price Deflator for Fuel and Lubricants

(15) MANINV = Gross Fixed Capital Formation in Manufacturing

(16) MANLAB = Workers in Manufacturing (millions of workers)

(17) N = Population (millions of workers)

(18) OTHINV = Gross Fixed Capital Formation in Other

(19) OTHLAB = Workers in Other (millions of workers)

(20) SERVINV = Gross Fixed Capital Formation in Services

(21) SERLAB = Workers in Services (millions of workers)

(22) TCINV = Gross Fixed Capital Formation in Transportation and Communication

(23) TCLAB = Workers in Transportation and Communication (millions of workers)

(24) TDH = Time Deposits in Hands of the Public

(25) WRTINV = Gross Fixed Capital Formation in Wholesale and Retail Trade

(26) WRTLAB = Workers in Wholesale and Retail Trade (millions of workers)

(27) XNAGCP = Non-Agricultural Output in Current Prices
B. Results of a Gauss-Seidel Simulation of Model II

In Table 2 we present the results of simulating Model II with a Gauss-Seidel simulation algorithm. The Gauss-Seidel routine is an iterative one, wherein the structural equations may be nonlinear in either the variables, parameters, or both. In contrast to the reduced form approach used for simulating Model I, where the equations of the reduced form of the structural model are solved simultaneously, the Gauss-Seidel algorithm solves the system of simultaneous structural equations directly for each year of the simulation period. The first year's values of the jointly dependent variables are read in as estimated values to begin the iteration for the solution of the model for the first year (1962). Then the solution values for 1962 are taken as the estimated values for 1963, and so on. Ultimately, we get a set of solution values for the jointly dependent variables for each year.

This approach varies from the reduced form approach in two ways. First, since the reduced form matrix of multipliers is not generated directly, multiplier analysis with the model must be carried out step-by-step by changing the value of one of the predetermined variables, resolving the system, then comparing the two solutions to get the implicit multiplier for that variable. Second, it is not possible to get a simulation of the model using the actual values of the lagged endogenous variables as we were able to do with Model I. Therefore, in Table 2 we present only one set of predicted values. These predicted values correspond to the second set shown in Table I, viz., the ** variables.
The main thing to note in comparing Tables 1 and 2 is that for the jointly dependent variables that are common to both models, the predictive performance, as reflected in the Theil U-Statistic, is very close. The U-Statistic is slightly lower in some cases and slightly higher in others. For the two cases that were the poorest for Model I, Agricultural Investment and Construction Output, we note the following. In the case of Agricultural Investment, the U-Statistic declines from .098 to .073. For the case of Construction Output, the change in the U-Statistic is very small, from .125 to .122, but the major errors in Model I appear in the later years, while those in Model II appear in the earlier years. From a forecasting point of view, the latter problem would seem to be less severe. Nonetheless, this equation continues to be a weak one in Model II, as it was in Model I. The rest of the equations perform very satisfactorily.

In short, the predictive performance of the more complex and flexible Model II remains good. This robustness in the general overall structure is encouraging in indicating that future and even more complex forms of the model will continue to fit and forecast successfully.
### TABLE 2
Actual and Forecast Values of Endogenous Variables of Model II from Gauss-Seidel Analysis

<table>
<thead>
<tr>
<th>YEAR</th>
<th>$FBT^A_t$</th>
<th>$FBT^{**}_t$</th>
<th>$RFLHOO^A_t$</th>
<th>$RFLHOO^{**}_t$</th>
<th>$COPE^A_t$</th>
<th>$COPE^{**}_t$</th>
<th>$FFHHE^A_t$</th>
<th>$FFHHE^{**}_t$</th>
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<tr>
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<td>948</td>
<td>181</td>
<td>181</td>
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<td>185</td>
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<td>144</td>
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<td>1016</td>
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<td>189</td>
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<td>178</td>
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<table>
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<th>$SER^{**}_t$</th>
<th>$TC^A_t$</th>
<th>$TC^{**}_t$</th>
<th>$RE^A_t$</th>
<th>$RE^{**}_t$</th>
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<th>GADJP$^{**}$</th>
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IV. SUGGESTION FOR FURTHER RESEARCH IN THE MACRO-MODELING EFFORT AND
SUMMARY AND CONCLUSIONS

A. Suggestions for Further Research

Anyone who engages in trying to construct a macroeconometric model is aware of many weaknesses and shortcomings in his product. This is particularly true for modeling efforts in developing countries because of some of the difficulties mentioned in the Introduction of this report. In many ways, a modeling effort is a never-ending process, with the model needing to be constantly updated, revised, and hopefully improved. Nevertheless, it is necessary at some point to make the current version (or versions) of the model available in order to solicit discussion, criticism, and recommendations. The models in this paper are presented in that spirit.

We see several areas in which further research is necessary; no doubt there are many others. In this section we discuss briefly a partial list of these areas to provide the reader with some notion as to the direction the current modeling effort will take.

1) The estimation of these models by Ordinary Least Squares is not satisfactory on grounds that are well known. We plan to reestimate the model by two Stage Least Squares by using Principal Components as the first-stage regressors.

2) In light of the overall purpose of the project, probably the major research that must be undertaken is that of the linkage of the macroeconometric model to the national linear programming model of Thai agriculture. This research is currently underway.
There are two possible ways that the macro-model of the nonagri­
cultural sector may be linked to the linear-programming model of the agri­
cultural equations of the macro-model to the equations of the linear pro­
gramming model and to solve the combined system of equations simultaneously. 
From a dynamic standpoint, such solutions could be obtained for successive 
time periods under alternative policy assumptions.

This method, however, provides some difficulties. First, given 
the present set of computer programs and computer resources at our dis­
posal, it forces the macro-model of the nonagricultural sector to be 
linear such as Model I, both in the parameters and in the variables. This 
is a very severe restriction on the specification of the macro model. 
The reason that it imposes a linearity constraint is that for a very 
large system of simultaneous equations, the only algorithm that we currently 
have that can solve such a large system is the linear programming algorithm, 
which is unable at present to handle nonlinearities. Solving the com­
bined system simultaneously would require either a modification of the 
L-P algorithm to allow for nonlinearities or the use of an alternative 
algorithm for solving systems of nonlinear equations, such as the Gauss­
Seidel technique. Either approach would entail a major programming effort 
in terms of computer size and solution time.

An alternative approach is to treat the combined ag and non-ag sector 
models in a block-recursive manner and therefore solve the two sector models 
separately. Because of the much smaller size of the non-ag macro model, 
a non-linear specification such as Model II will pose many fewer difficulties
in its solution. The linkage would then be recursive by temporal periods in the sense that a solution to the linear programming model of agriculture would be obtained subject to previous solved-for values of the non-ag macro variables. The resulting values of the agricultural variables which influence the non-agricultural sector of the economy will be fed into the macro model, which will then be re-solved, and so on.

Whether this recursive approach will prove satisfactory for simulating various policy proposals remains to be seen, but because of its greater computational simplicity, this will be our initial approach in the linkage of the two sector models. If it turns out that it appears necessary that a simultaneous solution technique be used, the programming effort to make this possible will then be undertaken.

3) The monetary and price sector, as mentioned above, is very rudimentary and really does not capture the workings of the financial sector satisfactorily. We plan to expand this sector considerably, including financial variables as explanatory variables in various sectors of the model, most particularly the investment sector. Also, we plan to expand this sector to analyze the Balance of Payments and foreign exchange position of Thailand. This would be of obvious interest because of the open nature of the Thai economy.

4) It is possible that having a model specification that is linear in the parameters is too restrictive and that improved performance might be gained by using nonlinear specifications. In the future, we plan to explore some possible nonlinear forms.
5) Because of the very important political and social implications of the distribution of income, one of the prime weaknesses in the present models in the level of aggregation of the income distribution sector. One of the most important areas for further research lies in the disaggregation of this sector and analysis of the underlying causes of the present distribution of income and policies that might change it in a way that is felt desirable by the Royal Thai Government.

6) As mentioned in Section III, some of the statistical measures reflecting the output equations are not particularly satisfactory, and further research in this area is called for.

7) Since a reduced form matrix of multipliers is not directly forthcoming from the Gauss-Seidel simulation of Model II, a rather extensive multiplier analysis of Model II will be carried out by changing the values of important predetermined variables and studying the comparative solutions of the model.

8) The construction of sub-models of the export commodities will be undertaken so as to gain a more complete (and less ambiguous) picture of these export markets. These structural sub-models may then be incorporated directly into the larger model.

9) Though the data base is very meager, clearly regional disaggregation of the macro-model would be of great interest. To the extent allowed by data availability, this area will be explored.

B. Summary and Conclusions

This paper presents two macroeconometric models of the Thai economy. As stated, they are transitional models in a larger modelling effort in
the Division of Agricultural Economics and should not be considered "completed" models. No model is ever "complete." Nevertheless, they provide a picture of the Thai economy for the period 1962-1974 and hopefully will serve as a building block for future model generations and as a stimulus to further macroeconometric modelling effort in Thailand.
V. Data Appendix

A. Data in Model I.

1. AGINV = Fixed Capital Formation in Agriculture.
   
sources: 1. Fixed Capital Formation in Agriculture in current prices.
   
   1962-1974, Unpublished data from NESDB.
   
   2. Total investment in current price.
   
   1969, table 5, p. 11, NA 1972-73 edition;
   
   3. Total investment in 1962 prices.
   
   1969, table 9, p. 15, NA 1972-73 edition;

2. AGLAB = Number of Workers in Agriculture.
   
sources: 1960, table 19, Population and Housing Census;
   
   1970, table 21, Population and Housing Census;
   

3. CCA = Capital Consumption Allowance.
   
   

1962-1966, Table 2, pp. 22-23, NA 1968-69 edition;
1967-1968, Table 2, p. 8, NA 1970-71 edition;
1969, Table 2, p. 8, NA 1972-73 edition;


1962-1966, Table 7, pp. 32-33, NA 1968-69 edition;
1969, Table 7, p. 13, NA 1972-73 edition;

4. COMP = Compensation of Employees.


1962-1974, the same as CCA.

5. CONSOUT = Construction Output.

1969, Table 7, p. 13, NA 1972-73 edition;


sources: 1962-1974, the same as COMP.
7. CROPOUT = Crop Output.
   sources: 1962-1974, the same as CONSOUT.

   sources: 1962-1965 = 0;

9. D 73 = Dummy Variable.
   sources: 1973 = 1;
   all other years = 0.

10. DINV = Change in Inventories.
    sources: 1962-1966, Table 9, pp. 36-37, NA 1968-69 edition;
    1969, Table 9, p. 15, NA 1972-73 edition;

11. DTCORP = Direct Taxes on Corporations.
    sources: 1962-1974, the same as COMP.

12. DTHH = Direct taxes on Households.
    sources: 1. Direct taxes on Household in current prices.
    1969, Account 4, p. 4, NA 1972-73 edition;
    2. Gross Domestic Product in current price and 1962
       prices.
    1962-1974, the same as CCA.

13. DXPBPMZ = Difference Between Export Prices and Bangkok Wholesale
    Price of Maize.
    sources: 1. Export price of Maize = \frac{\text{Total value of export}}{\text{Total quantity}}.

2. Bangkok Wholesale Price of Maize.
   1962-1974, Table V9, p. 97, Bank of Thailand April 2518.

14. FBT = Consumption of Food, Beverages, and Tobacco.
   1969, Table 8, p. 14, NA 1972-73 edition;

15. FFHHE = Consumption of Furniture, Furnishings and Household Equipment.
   sources: 1962-1974, the same as FBT.

16. FY = Farm Income.
   using 4% of Income from farms, professions and other unincorporated enterprises received by households.
   1967-1968, Table 6, p. 12, NA 1970-71 edition;
   1969, Table 6, p. 12, NA 1972-73 edition;

17. GADJP = Government Expenditures on Administration, Defense, Justice and Police.
   sources: 1962-1974, the same as FBT.

18. GDP = Gross Domestic Product.
1969, Table 7, p. 13, NA 1972-73 edition;

19. GGY = General Government Income From Property and Entrepreneurship.
    sources: 1962-1974, the same as COMP.

20. GREV = Government Revenue.
       1962-1974, the same as CCA.

    = Education and research + health services + special welfare services + other services.
    sources: 1962-1974, the same as FBT.

22. GTC = Government Expenditures on Transportation and Communication.
    sources: 1962-1974, the same as FBT.

23. IDTAX = Indirect Taxes.
    sources: 1962-1974, the same as CCA.

24. IMP 1 = Imports of Consumer Goods, Passenger Cars and Tires.
    sources: 1962-1974, Unpublished data from NESDB.
25. \( \text{IMP 2} = \) Imports of Intermediate Goods (Chiefly for Consumer Goods), Chassis and Bodies, and Fertilizers and Pesticides.

sources: 1962-1974, the same as IMP 1.

26. \( \text{IMP 3} = \) Imports of Fuel and Lubricants.

sources: 1962-1974, the same as IMP 1.

27. \( \text{IMP 4} = \) Imports of Capital Goods (not including Fertilizers and Pesticides), Buses and Trucks, and Intermediate Goods.

(Chiefly for Capital Goods)

sources: 1962-1974, the same as IMP 1.

28. \( \text{IMP 5} = \) Total Merchandise Imports in Balance of Payments.

\( (\text{IMP 1} + \text{IMP 2} + \text{IMP 3} + \text{IMP 4}) \)

sources: 1962-1974, the same as IMP 1.

29. \( \text{IMPSERV} = \) Imports of Services.

sources: 1962-1974, the same as IMP 1.

30. \( \text{INTCD} = \) Interest on Consumer Debt.

sources: 1962-1974, the same as COMP.

31. \( \text{INTPD} = \) Interest on Public Debt.

sources: 1962-1974, the same as COMP.

32. \( \text{M 1 P/PGDP} = \) Ratio of Price Deflator for IMP 1 to the GDP Price Deflator.


1962-1974, Unpublished data from NESDB.

2. GDP Price Deflator.

1962-1974, Unpublished data from NESDB.
33. \( M_2 \frac{P}{PGDP} = \text{Ratio of Price Deflator for IMP 2 to the GDP Price Deflator.} \)

sources: 1962-1974, same as \( M_1 \frac{P}{PGDP}. \)

34. \( M_4 \frac{P}{PGDP} = \text{Ratio of Price Deflator for IMP 4 to the GDP Price Deflator.} \)

sources: 1962-1974, the same as \( M_1 \frac{P}{PGDP}. \)

35. \( MGDP = \text{Manufacturing Output.} \)

sources: 1962-1974, the same as GDP.

36. \( MZE = \text{Output of Maize.} \)

1973-1974, Unpublished data from DAE.

37. \( NAGLAB = \text{Number of Workers in Non-Agriculture (1,000's of workers).} \)

sources: 1962-1974, the same AGLAB.

38. \( NAGINV = \text{Fixed Capital Formation in Non-Agriculture.} \)

sources: 1962-1974, the same as AGINV.

39. \( NFYPROW = \text{Net Factor Income Payment From the Rest of the World} \)

= \( NY - GDP + IDTAX + CCA. \)

40. \( NY = \text{National Income.} \)

= \( COMP + YUE + YPROP + DTCORP + GGY - INTCD - INTPD. \)

41. \( OTHAG = \text{Output of Agricultural Products other than Crops.} \)

sources: 1962-1974, the same as CONSOUT.

42. \( OTHOUT = \text{Output of other Non-Agricultural Products.} \)

sources: 1962-1974, the same as CONSOUT.
43. PDY = Personal Disposable Income
   = NY - DTHH + TRANIN - TRANOUT.

44. PFFHHE/P = Ratio of Price Deflator for the FFHHE to the Price
   Deflator for All Consumption.

   sources: 1. Price Deflator for the FFHHE = \( \frac{\text{FFHHE in current price}}{\text{FFHHE in 1962 price}} \).

   a. FFHHE in current prices.
      1969, Table 4, p. 10, NA 1972-73 edition;

   b. FFHHE in 1962 prices.
      1962-1974, the same as FFHHE.

2. Price Deflator for All Consumption.
   = \( \frac{\text{Total Private Consumption in current prices}}{\text{Total Private Consumption in 1962 prices}} \)

   a. Total Private Consumption in current prices.
      1962-1974, the same as FFHHE in current prices.

3. Total Private Consumption in 1962 prices.
   1962-1974, the same as FFHHE.

45. PRE/P = Ratio of Price Deflator for RE to the Price Deflator
   for All Consumption.

   sources: 1962-1974, the same as PFFHHE/P.

46. PSERV/P = Ratio of Price Deflator for SERV to the Price Deflator
   for All Consumption.

   sources: 1962-1974, the same as PFFHHE/P.
47. PTC/P = Ratio of Price Deflator for TC to the Price Deflator for All Consumption.
   sources: 1962-1974, the same as PFFHHE/P.

48. RAGTLAB = Ratio of Agricultural Labor to Total Labor Force.
   sources: 1962-1974, the same as AGLAB.

49. RE = Consumption Expenditure on Recreation and Entertainment.
   sources: 1962-1974, the same as FBT.

50. RFLHHO = Consumption Expenditure on Rent, Fuel, Light and Household Operation.
   sources: 1962-1974, the same as FBT.

51. Rice = Output of Rice
   1972-73 edition;
   1973-1974, Unpublished data from DAE.

52. RNATLAB = Ratio of Non-Agricultural Labor to total Labor Force.
   sources: 1962-1974, the same as AGLAB.

53. RUB = Output of Rubber.

54. SD = Statistical Discrepancy.
    = GDP - TPCE - TGCE - TX + TIMP - TINV.

55. SERGDP = Output of Sercices.
   sources: 1962-1974, the same as CONSOUT.

56. SERV = Consumption Expenditures on Services.
   sources: 1962-1974, the same as FBT.

57. TAP = Output of Tapioca (Cassava meals).
1973-1974, Unpublished data from DAE.
(Converted at 392 kgs meals per ton of roots)

58. TC = Consumption Expenditure on Transportation and Communication.
sources: 1962-1974, the same as FBT.

59. TCOUT = Output of Transportation and Communication.
sources: 1962-1974, the same as CONSOUT.

60. TGCE = Total Government Consumption Expenditures.
sources: 1962-1974, the same as FBT.

61. TIMP = Total Imports.
sources: 1962-1974, Unpublished data from NESDB.

62. TINV = Total Fixed Capital Formation.
sources: 1962-1974, the same as DINV.

63. TPCE = Total Personal Consumption Expenditures.
sources: 1962-1974, the same as FBT.

64. TRANIN = Net Transfers to Households from Government and the Rest of the World.
= Current transfers from general government + Current transfers from the rest of the world.
sources: 1962-1974, the same as DTHH.

65. TRANOUT = Net Transfers from Households to Government and ROW
= Other current transfers to general government + transfers to the rest of the world.
sources: 1962-1974, the same as DTHH.
66. TX = Total Exports.
   sources: 1962-1974, Unpublished data from NESDB.

67. TYUE = Total Income From Unincorporated Enterprises.
   sources: 1962-1974, the same as DTHH.

68. WRTOUT = Output of Wholesale and Retail Trade.
   sources: 1962-1974, the same as CONSOUT.

69. XMFG = Exports of Manufactured Goods.
   \[ XMFG = \frac{\text{Export of manufactured goods + machinery + misc. man. goods}}{\text{Export of merchandise price deflator}} \]
          1962-1974, Table III 4 col. 7+8+9, p. 43, BOT April 2518.
          2. Export of merchandise price deflator.
             1962-1974, Unpublished data from NESDB.

70. XMZE = Exports of Maize.
   \[ XMZE = \text{Quantity of export x 1962 price.} \]
   sources: 1962-1974, Table III 7, pp. 50-51, BOT April 2518.

71. XOTH = Exports of Other Goods.
   \[ XOTH = \text{Total of Export} - (EXRICE + XRUB + MZE + XTAP) - XMFG - XSERV. \]
   sources: 1. Total of Export and XSERV.
          1962-1974, Unpublished data from NESDB.
          2. EXRICE + XRUB + XMZE + XTAP.
             1962-1974, the same as XMZE.
72. \( X_{\text{PRICE}} = \frac{\text{Value of Price Export}}{\text{Export Quantity}} \)

sources: 1962-1974, Table III 7, pp. 50-51, BOT April 2518.

73. \( X_{\text{PRUB}} = \frac{\text{Value of Rubber Export}}{\text{Export Quantity}} \)

sources: 1961-1974, the same as \( X_{\text{PRICE}} \).

74. \( X_{\text{RICE}} = \text{Exports of Rice}. \)

\( = \text{Quantity of Export} \times 1962 \text{ price}. \)

sources: 1962-1974, the same as \( X_{\text{PRICE}} \).

75. \( X_{\text{RUB}} = \text{Exports of Rubber}. \)

\( = \text{Quantity of Export} \times 1962 \text{ price}. \)

sources: 1962-1974, the same as \( X_{\text{PRICE}} \).

76. \( X_{\text{SERV}} = \text{Export of Services}. \)

sources: 1962-1974, Unpublished data from NESDB.

77. \( X_{\text{TAP}} = \text{Exports of Tapioca}. \)

\( = \text{Quantity of Export} \times 1962 \text{ price}. \)

sources: 1962-1974, the same as \( X_{\text{PRICE}} \).

78. \( Y_{\text{PROP}} = \text{Income from Property} \)

sources: 1962-1974, the same as \( \text{COMP} \).

79. \( Y_{\text{UE}} = \text{Income from Unincorporated Enterprises other than Farms}. \)

sources: 1962-1974, the same as \( \text{FY} \).

B. Data in Model II.

1. \( A_{\text{GOUT}} = \text{Total Output in Agriculture}. \)

Sources: 1962-1966, Table 7, pp. 32-33, NA 1968-69 edition;

\( 1967-1968, \text{Table 7, p. 13, NA 1970-71 edition}; \)
1969, Table 7, p. 13, NA 1972-73 edition;

2. CHP = Currency in Hands of the Public.
   sources: 1962-1974, Table I. 3, p. 6, Bank of Thailand
            April 2518.

3. CONLAB = Workers in Construction (millions of workers).
   sources: 1960, Table 19, Population and Housing Census;
            1970, Table 21, Population and Housing Census;
            rate.

4. DDH = Demand Deposits in Hands of the Public.
   sources: 1962-1974, the same as CHP.

5. GDPCP = Gross Domestic Product.
   sources: 1962-1966, Table 2, pp. 22-23, NA 1968-69 edition;
            1967-1968, Table 2, p. 8, NA 1970-71 edition;
            1969, Table 2, p. 8, NA 1972-73 edition;

6. M 3 P = Price Deflator for Fuel and Lubricants
   sources: 1962-1974, Unpublished data from NESDB.

7. MANLAB = Workers in Manufacturing (millions of workers).
   sources: 1962-1974, the same as CONLAB.

   sources: 1960 and 1970, Dr. Leroy Blakeslee adjusted then from
            1960 and 1970 Population and Housing Census;
            1962-1969 Estimation by using growth rate;

9. OTHLAB = Workers in Other (millions of workers)
sources: 1962-1974, the same as CONLAB.

10. SERLAB = Workers in Services (millions of workers)
sources: 1962-1974, the same as CONLAB.

11. TCLAB = Workers in Transportation and Communication (millions of workers).
sources: 1962-1974, the same as TCLAB.

12. TDH = Time Deposits in Hands of the Public.

13. WRTLAB = Workers in Wholesale and Retail Trade.
sources: 1962-1974, the same as CONLAB.

sources: 1962-1974, the same as GDPCP.

15. CONSINV = Gross Fixed Capital Formation in Construction.
MANINV = Gross Fixed Capital Formation in Manufacturing.
OTHINV = Gross fixed Capital Formation in Other.
SERVINV = Gross Fixed Capital Formation in Services.
TCINV = Gross Fixed Capital Formation in Transportation and Communication.
WRTINV = Gross Fixed Capital Formation in Wholesale and Retail Trade.
The variables which are mentioned above are derived as follows:

1. Proportions of Total Gross Fixed Capital Formation for each Industry group for the 1967-1974 Investment data were computed.

2. A regression was run with these proportions regressed on time, and then were extrapolated back to 1961.

3. The extrapolated proportions were then multiplied by actual Total Gross Fixed Capital Formation for the 1961-1966 period to get industry investment figures.

16. \( K_{AG} \) = Capital Stock in Agriculture.
    \( K_{CONS} \) = Capital Stock in Construction.
    \( K_{MAN} \) = Capital Stock in Manufacturing.
    \( K_{OTH} \) = Capital stock in Other.
    \( K_{SERV} \) = Capital Stock in Services.
    \( K_{TC} \) = Capital Stock in Transportation.
    \( K_{WRT} \) = Capital Stock in Wholesale and Retail Trade.

The variables which are mentioned above are derived as follows:

1. It was assumed that the output - capital ratio is approximately equal to the marginal output-capital ratio.

2. For the aggregate groups, Agriculture and Non-Agriculture, the average of the marginal output-capital ratios for 1962-1974 was computed.

3. For the base year 1962, it was assumed that the actual output-capital ratio was equal to this average ratio and the capital stock for agriculture and non-agriculture was estimated for 1962.
4. The capital stocks for the industry groups were then calculated using the same proportions used in calculating the investment data.

5. Capital stock for later years was calculated simply by adding the investment figures to the 1962 benchmark capital figure.